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A STUDY ON NANO STRUCTURED PLATES BEHAVIOR UNDER LOW VELOCITY IMPACT LOADING

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ABSTRACT - An economical and viable option to conventional and high rate materials is the use of fiber glass/epoxy composites, but for impact applications their toughness still has to be enhanced. The toughness and additional mechanical properties can be improved by using very small amount of PET into an epoxy system. In the present work epoxy modified by way of MMT Clay (3 wt % of Epoxy) & PET fiber is manufactured using hand layup system. The nano composites have been characterized using Impact, Tensile, Bending and Microhardness tests. The mechanical properties are compared by means of those found for PET introduced epoxy nano composites. The mechanical test shows that the presence of 1 wt% PET fiber largely increases impact strength and flexural strength. Micro hardness decreased at PET fiber loading.

KEYWORDS :- PET -Polyethylene Terephthalate, WT-Weight, ASTM- American Standard Test Method.

I. INTRODUCTION

In 1946, the first industrially-produced epoxy resin was introduced to market. Since then, the use of thermosetting polymers has steadily increased. The term epoxy resin refers to both the polymer and its cured resin/hardener system. The former is a low molecular weight oligomer that contains one or more epoxy groups per molecule (more than one unit per molecule is required if the resultant material is to be cross-linked). The characteristic group, a three-member ring known as epoxy, epoxide, oxirane, glycidyl or ethoxyline group is highly strained and therefore very reactive. Epoxy resins can be cross-linked through a polymerization reaction with a hardener at room temperature or at elevated temperature (latent reaction). Curing agents are used for room temperature cure are usually aliphatic amines, whilst commonly used higher temperature, higher performance hardener are aromatic amines and acid anhydrides. However, an increasing number of specialized curing agents, such as poly-functional amines, polybasic carboxylic acids, mercaptans and inorganic hardener are also used. All of these results in different, tailored properties of the concluding polymer matrix. In general, the higher temperature Cured resin systems have improved properties, such as higher glass transition temperatures, strength and stiffness, compared to those cured at room temperature.

II . MATERIALS

Montmorillonite Clay:
Clay as nano particles such as Semitic clays (Montmorillonite) are incorporated into polymers to form resulting polymer nano composite, which may possess unique electrical, mechanical and optical properties.

Polyethylene Terephthalate (PET):
Polyethylene Terephthalate, commonly abbreviated as PET, PETE or the obsolete PETP or PET-P, is a thermoplastic polymer resin of the polyester family and is used in synthetic fibers; beverage, food and other liquid containers; thermoforming applications; and engineering resins often in combination with glass fiber.
Recron fibers PET (Poly ethylene Terephthalate), Diameter - 15μm, Length – 3mm are sold by Reliance India Ltd.

Epoxy Resins & Hardener:
Epoxy resins, also known as epoxide resins, are a class of polymers, containing reactive groups which are converted to thermosets resins by reaction with compounds known as curing agents

Mbrace Saturant	Epoxy	Hardener
Appearance	Blue translucent liquid	Clear, colour less to slight amber low viscosity liquid
Specific gravity	0.950 - 1.150 g/cm^3 at 23ºC	0.96 - 1.00 kg/L at 23ºC
Solubility in water	Insoluble	Insoluble Hydrophobic.

Boiling point/ Flash point	> 200ºC	> 100ºC

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III. EXPERIMENTAL METHODOLOGY

Mixing of Nanoclay into Epoxy (base):
Preparation of Nanoclay: Before mixing the Nanoclay into the epoxy base, Nanoclay was dried at 1200C for 2 hours in a vacuum oven.
Mechanical stirring: Epoxy base is a blue colour thick fluid. It is quite difficult to mix nano silicates into it manually. So we used a mechanical stirrer and an oil bath for proper mixing of nanoclay. Oil bath was used to heat up the epoxy to desired (800 C) temperature, so that the viscosity of epoxy base is reduced. Proper mechanical stirring of epoxy at this stage resulted in a better dispersion of clay. Weight percentages of clay 3 % by weight of epoxy, were added and stirred at a temperature of 800 C for 1 hour.
Ultrasonication after Mechanical Stirring: Sonication is an act of applying sound energy to agitate particles in a sample, for various purposes. In the laboratory, it is usually carried out using an ultrasonic bath or an ultrasonic probe, colloquially known as a sonicator. Sonication can be used to speed dissolution, by breaking intermolecular interactions. Sonication was done for evenly dispersing nano particles in liquids. After mechanical stirring of the epoxy solution container was placed into the ultrasonication bath for up to 3 hours at 300 temperatures.
Preparation of PET Fibers: In order to improve the adhesion between the fiber and the matrix, the PET fibers were subjected to alkaline hydrolysis. The fibers were treated with a NaOH aqueous solution (50% w/v) at 800C for 2.5 min., then fibers were washed with distilled water until all the sodium hydroxide was eliminated and the water used for washing the fibers no longer gave any alkalinity reaction. Subsequently, the surface-treated fibers were dried at 600C for 24 h in a vacuum oven.
Mixing of Epoxy Base solution with modified treated PET fibers:After ultrasonication, PET fibers mixed into the solution in different ratios (0, 0.25, 0.5, 0.75 & 1% by volume). After mixing, manual stirring up to 5 to 10 minutes was done.
Mixing of Epoxy Base & PET Solution with Hardener:
After ultrasonication, the solution is mixed with the hardener in the ratio 10:4 by volume. After mixing, manual stirring for 5 to 10 minutes was done.
Making the PET/Epoxy Composite Sheets:
The mixture was then poured into the mould and applied uniformly using the hand layup method. Due to low viscosity, the solution maintained uniformity by self. After applying epoxy, the sheet was left overnight to dry. The full curing of sheet was done by leaving it under ambient temperature for at least seven days before processing further.Specimen
Specifications:
The dimensions of specimens are shown below.

Table 1: Specimen Specifications for Testing

Parameter for Specimen	Specimens for Tensile Testing	Specimens for Impact Testing	Specimens for Bending Testing
Length	125 mm	62 mm	125mm
Width	15mm	10 mm	12.7mm
Thickness	4mm	4mm	4mm

IV. RESULTS & DISCUSSION

1. IMPACT TEST RESULTS:

Impact strength or toughness is the main property of materials. Fig. 1 shows the results that are observed while doing the Charpy Impact test on the test samples with different loading of PET fiber. From fig. 1, we can say that the impact strength increases with an increase in the PET content. Fig. 1 clearly shows that as we increase the PET content from 0% to 1% the impact strength increases by 35%.
According to "Teh et al (2005)" the fracture toughness of neat epoxy increases by about 33% from 0.70 to 0.93 MPa-m1/2 upon incorporating 1 wt% untreated PET fibers. When incorporating only 1 wt% PET fibers treated by NaOH for 2.5 min, compared with neat epoxy, the fracture toughness of the composite increases by about 80%, indicating a significant toughening effect using the surface-modified PET fibers (for 2.5 min surface treatment by NaOH), probably due to improved interfacial adhesion between the fiber and the matrix.
But we have used the Epoxy and Clay material which is different used by the "Teh et al (2005)". So our material toughness increases 35% when added 1% PET modified fiber.

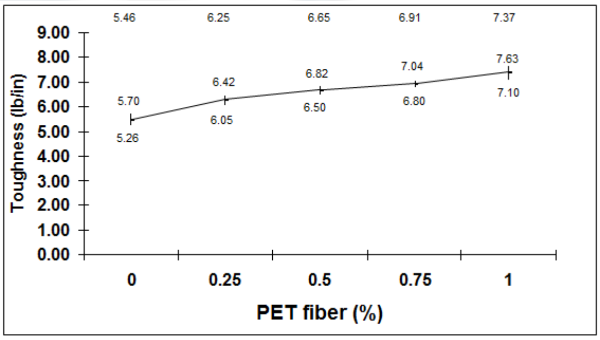

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Fig 1: Toughness vs PET fiber contents

2. *X-ray Diffraction Test Results:*

The X-ray Diffraction experiments were conducted on the samples having different nanoclay loading. But our all samples are made by same amount (3% wt) of nano clay, so we perform X-ray Diffraction test only on one sample. X-ray diffractometer gives the values of d-spacing and 2θ nano composites.
XRD result clearly shows that the epoxy chains have intercalated into the nano clay layers. This has been inferred from the peak at 4.854 as shows in graph visa us the 2 theta is equal to 1148 for pure Closite 30B. Fig. 2 clearly shows the analysis of XRD

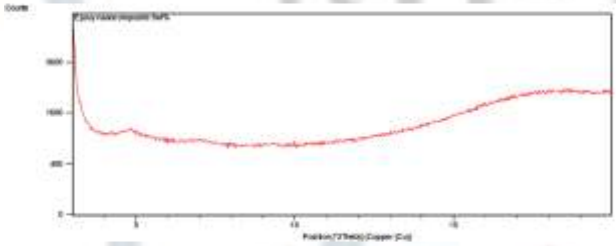
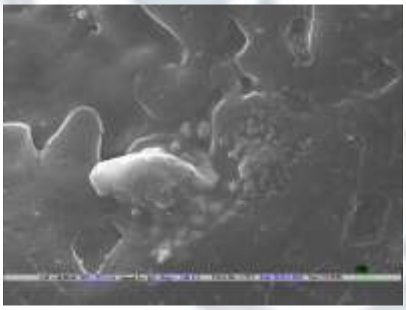
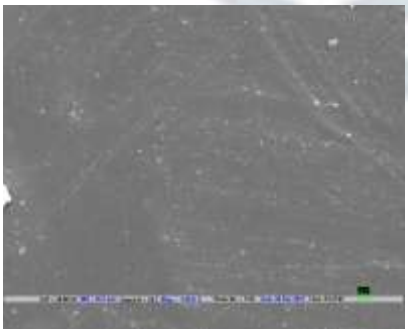


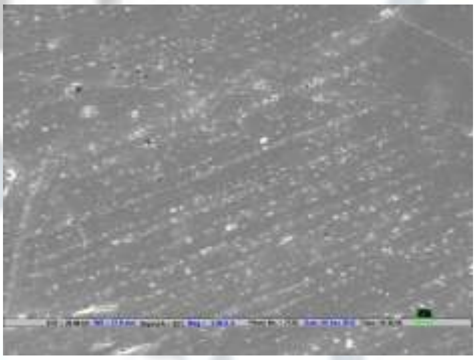
Fig 2: X-ray diffractogram for 3% wt nano clay

3. Scanning Electron Microscope (SEM)

SEM was used to determine size and distribution of particles in the samples for the five polymer nanocomposite systems. The primary goal of using SEM was to determine particle dispersion.
Scanning electron microscopy was used in this study to obtain high magnification photos of the polymer fiber epoxy nano composites to observe their structures in order to relate with the resulting properties. Images of several different clay loading samples were obtained at 5000X magnification..







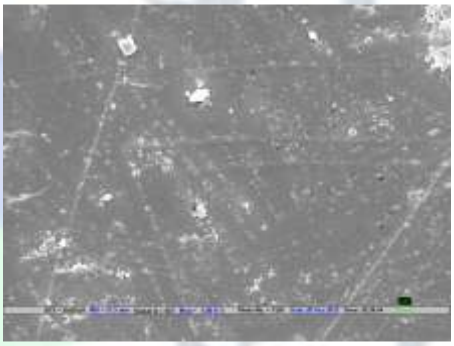


Fig 3.1 SEM image of nanocomposite having 0% wt PET fiber loading, Fig 3.2 having 0.25% wt PET fiber loading, Fig 3.3 having 0.5% wt PET fiber loading, Fig 3.4 having 0.75% wt PET fiber loading, Fig 3.5 having 1% wt PET fiber loading

Fig 3.1 shows the structure of nano composite without mixing the PET fiber. We show without PET fiber epoxy have not proper bond, so don't make plane layers. Fig 3.2 shows the image of nano composite with mixing of 0.25% PET fiber. In fig white spots are shows the PET fibers. Some holes are also shows in image, which show fiber, remove from that place during tensile test.
Fig 3.3 & fig 3.4 shows the image for nano composite with mixing 0.50% & 0.75% PET fiber. In image shows some white straight lines that are PET fiber in horizontal position. And we also show with increase the %age of PET fiber increase the white area in the image.
Fig 3.5 shows the image of nanocomposite with mixing of 1% PET fiber. In this image some white spot are large which show the PET fiber are in vertical position and straight lines shows the PET fiber in horizontal position.
In all images we clearly see with mixing of PET fiber into the nano composite, matrix make the proper bond and also make the plane layers.

V.CONCLUSIONS AND FUTURE SCOPE

PET introduced nano composites have been manufactured using epoxy as matrix. PET was added to epoxy in different weight percentage (1 wt%, 0.75 wt%, 0. 5 wt%, 0.25 wt % & 0 wt% of weight of resin). For the processing of epoxy-PET mechanical stirring and ultrasonication was done. The composites were manufactured using hand layup method and characterized using Tensile, Bending, Microhardness & Impact Tests. Tensile, bending and Impact tests were performed on nano composites as per ASTM standards.
Impact strength increases with the increase PET content. we have used the Epoxy and Clay material which is different used by the "Teh et al (2005)". So our material toughness increases 35% when added 1% PET modified fiber. XRD result clearly shows that the epoxy chains have intercalated into the nano clay layers. Scanning electron microscopy was used in this study to obtain high magnification photos of the polymer fiber epoxy nano composites to observe their structures in order to relate with the resulting properties. Images of several different clay loading samples were obtained at 5000X magnification.

Future Scope

The experiment can be performed on polyester as matrix system, since with this matrix the barrier properties of composites can be enhanced.
Clay loading can also be varied more than 3 wt%.
The duration of current experiment can be increased to see the effect in long term.
PET loading can be increased to 2-3 wt% if PET loading is done mechanically.
PET stickiness can be increased to large extent by washing the PET fiber for more time in NaOH, to get other properties.

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